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PROGRESS REPORT 1958-1959

COOPERATIVE SNOW MANAGEMENT RESEARCH

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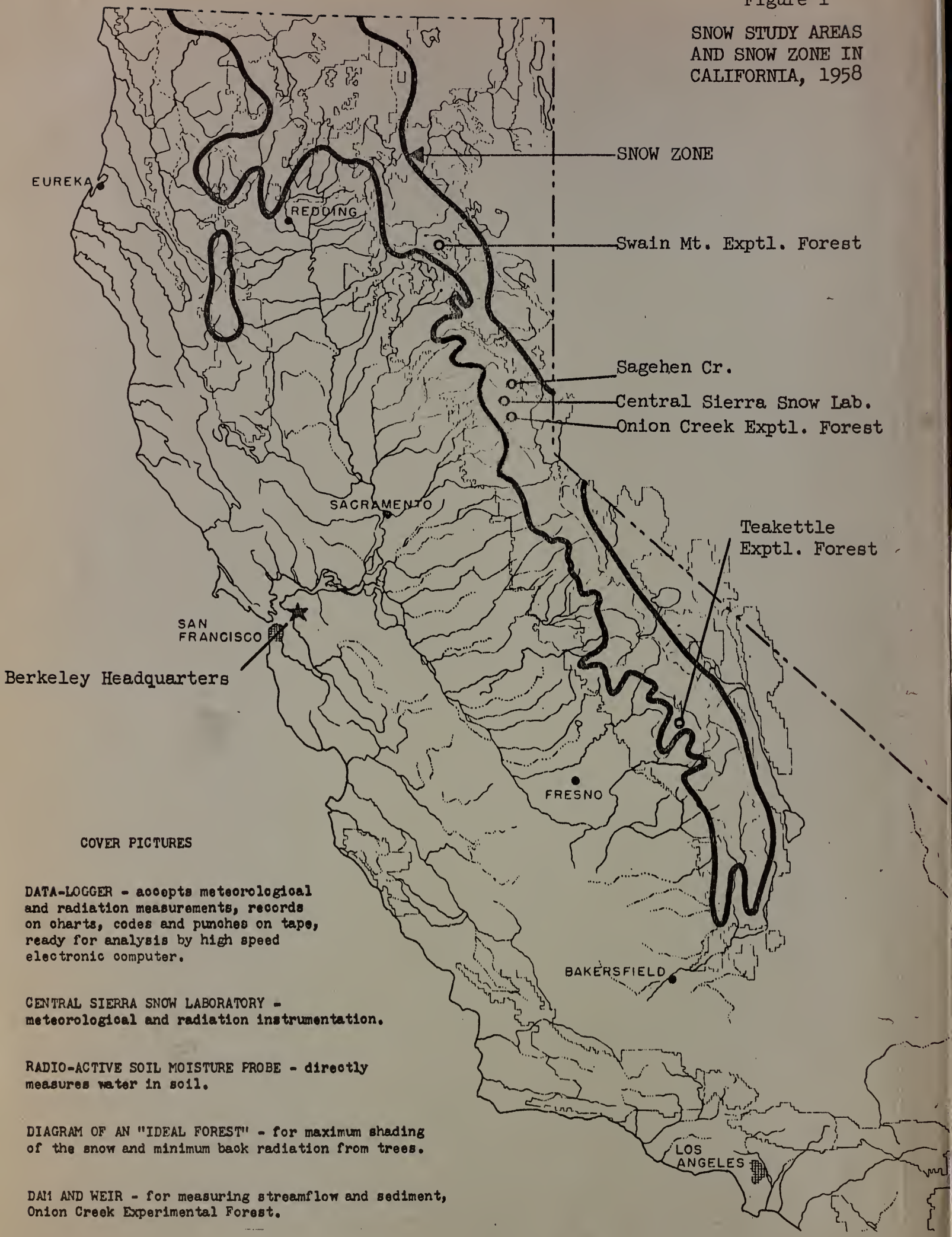
Figure 1

SNOW STUDY AREAS AND SNOW ZONE IN CALIFORNIA, 1958



COVER PICTURES

DATA-LOGGER - accepts meteorological and radiation measurements, records on charts, codes and punches on tape, ready for analysis by high speed electronic computer.

CENTRAL SIERRA SNOW LABORATORY - meteorological and radiation instrumentation.

RADIO-ACTIVE SOIL MOISTURE PROBE - directly measures water in soil.

DIAGRAM OF AN "IDEAL FOREST" - for maximum shading of the snow and minimum back radiation from trees.

DAM AND WEIR - for measuring streamflow and sediment, Onion Creek Experimental Forest.

SUMMARY

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June 30, 1959

PROGRESS REPORT, 1958-59

CALIFORNIA COOPERATIVE SNOW MANAGEMENT RESEARCH

by

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Pacific Southwest Forest and Range Experiment Station

with cooperation of

State of California, Department of Water Resources

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SUMMARY

In July 1956, the U. S. Forest Service and the State of California started research aimed at developing and testing ways of improving California's water yield through management of land in the snowpack zone. Our 1957-58 Progress Report (11) described the eighteen separate studies under way and summarized the results for the first two years of the study. This report gives the results for the third year.

Nine technical papers were published during the past year on subjects ranging from "Selection of 'best' snow course points," to "Forest shade related to snow accumulation," to "Winter and summer water losses in the High Sierra."

Snow has been measured at some seventy snow courses, representing many conditions of natural forest stands, forests logged in a variety of ways--strip cut, block cut, and commercial diameter-limit cut, and brushfields, natural and converted.

Soil moisture losses during summer have been measured at some three hundred points, representing various slopes, forest conditions, types of logging, and ground cover conditions.

Winter evaporation losses from snow have been measured in forest stands and forest openings, in large meadows, and on exposed ridges and slopes.

Two new dams and stream gaging stations were constructed on the Onion Creek watersheds in the summer of 1958; streamflow and sediment measurements have been taken on the eleven experimental watersheds distributed in the headwaters of five major California river basins.

This year was one of very light snowpack, giving the research program an essential contrast to the extremely heavy year of 1958.

Plans for the coming year are to concentrate field work on the studies now under way, and to analyze the data currently. We should be ready by midwinter to start plans for formal plot testing of the "best" methods of managing forests and brushlands for water.

Financing and cooperation in the project are such as to make for rapid progress. The State's contribution for the research is $65,000 this year. The Forest Service is matching this amount and conducting the research. Other agencies continue to lend a hand: Pacific Gas and Electric Company, the Weather Bureau, and the Department of Zoology at the University of California.

Reprints of published papers are available, and other information is available upon request. To make this information more accessible, a detailed index has been included as part of this report. Inasmuch as this is to a large extent a continuation report, pages numbered herein start with page 57.

EQUIPMENT BREAK-THROUGHS

The Radio-active Soil Moisture Probe has proven to be a major break-through in determining water losses from various forest sites. Shown on the cover is a technician lowering the probe into an aluminum access tube. The probe gives off fast neutrons which penetrate the surrounding soil. The fast neutrons are slowed down when they hit the light-weight hydrogen atoms in water, but bounce off everything else. Thus the number of slow neutrons resulting is proportional to the amount of water in the soil. Inside the probe a counter similar to a geiger counter detects the slow neutrons, and on a scaler we can immediately read off the amount of water left in the soil. Difference between readings taken in early spring and late fall are a measure of summer water losses.

The CSSL Hemispherical Photocanopymeter, a simple pinhole camera with very short "focal" length, is speeding determination of forest conditions at our experimental sites. The camera is merely a box which holds cut or pack film a distance of 0.315 inches from a pinhole. The camera is pointed upward and the film exposed for 2 to 8 seconds. The result is a picture of the forest cover and surrounding topography in 85 percent of the hemisphere. Simple percentage and solar path grids placed over these pictures give rapid measures of the forest canopy cover and shade.

Our Micrometeorological Data-logger is taking wind, humidity, temperature, and radiation measurements directly from the field instruments and punching a tape, coding the measurements for analysis by electronic computers. The readings of each instrument are at the same time printed on a chart, so that the operation of the instrument can be visually checked. As many as 144 instruments can be read in sequence on either a six minute or a one hour schedule. Minor adjustments and "de-bugging" are still needed before continuous, trouble-free operation is expected.

PROGRESS REPORT, 1958-59

CALIFORNIA COOPERATIVE SNOW MANAGEMENT RESEARCH

by

Henry W. Anderson and Lucille G. Richards

INTRODUCTION

Studies are under way in California to develop and test methods of managing forests and other lands in the snow zone for improved water yield. The studies are being made by the Pacific Southwest (formerly California) Forest and Range Experiment Station of the U. S. Forest Service with the cooperation of the Department of Water Resources of the State of California.

Water managers are asking and will continue to ask for estimations of the effects on water yields of a wide variety of land management practices. Since tomorrow's demands for water may be completely different from today's, our research is attempting to span the possible practices, as well as evaluate the immediately practical. Thus we are studying the effects on water of ordinary commercial logging practices and of strip and block cutting of various widths and sizes. At the same time we are developing logging practices aimed at specific water objectives such as maximizing the total delivery of water or delaying the delivery of water into late spring. Consequences of each practice in terms of water quality, sedimentation, and flood discharges are also being evaluated.

KINDS OF STUDIES

This is a report of progress during 1958-59 in each of eighteen studies now under way. The objectives and methods of each study were outlined in detail in the 1957-58 Progress Report (11). This report will concentrate primarily on results and on plans. The studies are four kinds:

1. Inventories of present conditions of:

Water yield	(Study No. 1-10)
Land conditions	(Studies No. 1-1, 1-5),
Soil erodibility	(Study No. 1-18).

2. Studies of basic meteorology, snow, and heat balance (Studies No. 1-6, 1-9, 1-14).

3. Development of methods of improving water yield and controlling sediment (Studies No. 1-4, 1-7, 1-8, 1-11, 1-13, 1-15, 1-16).

4. Pilot tests of various forest and land management methods on experimental watersheds for their effects on streamflow and sedimentation (Studies No. 1-2, 1-3, 1-12, 1-17).

Detailed plans of these studies are available for inspection upon request.

THE SIX STUDY AREAS

The general location of each study area is shown on the map inside the front cover. The principal activities at each study area are:

1. Berkeley Headquarters--project headquarters, inventories and analysis.

2. Swain Mountain Experimental Forest (Feather River)--plot studies of the effects of cutting forests in strips and blocks, slash disposal, and game management on snow accumulation and soil moisture losses.

3. Sagehen Creek (Truckee River)--plot and watershed tests to relate the effects of land treatment on water yield, floods, sedimentation, and fish habitat.

4. Central Sierra Snow Laboratory (Yuba River)--studies of basic meteorology, snow physics, and forest hydrology. Special study of the effects and method of evaluation of effects of commercial logging and freeway construction on streamflow and sedimentation.

5. Onion Creek Experimental Forest (American River)--plot tests of the effects of commercial logging and of brush conversion on snow and moisture losses; calibration of experimental watersheds for evaluation of the management methods developed.

6. Teakettle Experimental Forest (King's River)--calibration of watersheds to test the effect of forest cutting and grazing practices on streamflow and sedimentation.

Inventory of Sierra Hydrologic Characteristics (Study No. 1-1)

An inventory of the forest and land conditions and topography of the Sierra westside above 5,000 feet elevation has been completed. The kinds of forests and their densities, sizes of openings and their ground conditions (brush, grass-herb, bare ground, or rock outcrop), have been determined from analysis of air photographs. A systematic sample of 331 40-acre plots constituted the sample. These are some overall results:

	Percent of Area
Forested (Canopy cover greater than 15%) - - - -	42
Non-forested	
Bare ground and rock - - - - - - - - - - - - -	29
Brush covered - - - - - - - - - - - - - - - -	17
Grass-herb - - - - - - - - - - - - - - - - - -	7
Other, tallus, crops, lakes etc. - - - - - - -	5
	100

The results of the inventory are summarized in Table 1.

Plans--A report will be prepared giving detailed breakdown of the inventory of forest and land conditions by slopes, elevations, and latitudes. The inventory will be extended to include the Sierra westside elevations between 500 and 5,000 feet.

Onion Creek Experimental Watersheds (Study No. 1-2)

Two more dams were constructed and gaging stations installed in the Onion Creek Experimental Forest. Streamflow and sediment measurements were initiated in these two watersheds in September 1958, bringing the total number of gaged and measured streams to five in this experimental forest. One of the small dams is shown on the cover.

Characteristics of the installations and the watersheds are summarized in Table 2, Appendix A. Daily discharges for the water year 1957-58 are currently being computed. Maximum discharges for the year 1958-59 occurred between April 4 and April 29, and were:

	Maximum Yearly Discharge c.f.s./sq. mi.
Onion Creek No. 1	10
No. 2	13
No. 3	11
No. 5	20
No. 7	14

Three reservoirs were surveyed to determine sedimentation for 1957-58. Sediment deposition ranged from 0.083 to 0.112 A.F./Sq. Mi. (Table 2).

We have made arrangements with the USGS to check the gaging stations and publish the discharge records in their regular Water Supply Papers.

Plans--We plan to gage these watersheds and measure sediment annually for a period of at least five years, to calibrate them before treatment.

The Department of Water Resources and the USGS are installing a gaging station below our experimental watersheds. This will serve as an overall check on streamflow. The USGS will operate the station; we will service the station during our periodic visits to Onion Creek.

Stream Gaging and Sediment Measurements at Teakettle Experimental Watersheds, Kings River (Study No. 1-3).

This is another set of five High Sierra watersheds being calibrated in preparation for evaluation of the effects of forest cutting and grazing on streamflow and sedimentation. The characteristics of the watersheds and the measurement devices are summarized in Table 2, Appendix A, together with the annual sediment production for the water year 1958. Sediment production was very low, 0.007 to 0.055 A.F./Sq. Mi. (Table 2), despite the heavy runoff year. Annual streamflow for the 1958 water year was about 32.6 inches. Peak discharges for 1958-59 were:

	Maximum Yearly Discharge c.f.s./sq. mi.
Teakettle No. 1	10
No. 2	10
No. 2a	12
No. 3	21
No. 7	7

A soil, vegetation, and timber stand survey of the Teakettle Experimental Area was completed this year. This survey will be invaluable in treatment evaluation.

Plans--We plan to continue to gage the watersheds and measure sediment deposition annually for a minimum additional period of two years before attempting calibration of the watersheds and design of treatments. We plan to have the USGS continue to inspect the stream gaging stations periodically and we will work up the records so that they may be published in the regular USGS Water Supply Papers.

Cooperation--The Pacific Gas and Electric Company has generously cooperated in servicing these Teakettle gaging stations during the winter months.

Inventory of Forest Conditions at the Central Sierra Snow Laboratory Snow Courses (Study No. 1-4).

This study is complete. Any further studies of the evaluation of forest conditions will be carried on under Study 1-11.

The results of these studies have been published in three papers: (See publications numbers 1, 6, and 14, at the end of this report.)

The first paper (1) analyzes snow accumulation and melt as related to the forest as expressed by the shade of the trees to the south and back radiation from trees to the north. The results are interpreted as to how a forest might be cut to produce the ideal forest for snow accumulation (see cover). By cutting successive strips of forest to the southward a wall-and-step forest would be produced, resulting in maximum shade from trees to the south and minimum radiation from trees to the north of the cut strip. Strips could be wider on north slopes than on south, for the same shade.

The second paper (6) tests relation of snow accumulation and melt to topographic, exposure, and forest variables. It shows that slope and exposure effects on snow accumulation and melts may be better expressed in terms of the energy they receive than the conventional terms of steepness of slope and direction of slope. Shelter of the snow from wind by nearby trees and trees as far away as one quarter of a mile were evaluated.

The third paper (14) compares various expressions of the forest on snow accumulation. Simple variables like hemispherical cover were evaluated as were complex seven variable expressions of forest effects. The best relation of forest variables to snow accumulation was obtained from variables specifically designed to index the separate effects of forest on interception, solar radiation received at the snow surface, back radiation from trees, and interchange of energy between the forests, the clouds, and the sky.

The results of these studies are helping to guide analyses of data which will show the differential effects of forests and forest cutting on various slopes on snow accumulation.

Soil Vegetation Surveys of Castle Creek Laboratory Basin (Study No. 1-5).

This study is complete. The results were published in publication number 5. (See list of publications at the end of this report). The data on soil, ground vegetation, and timber stands, have been used as a basic guide in three studies: 1-11, 1-13, 1-15.

Basic Meteorological and Snow Measurements, Central Sierra Snow Laboratory (Study No. 1-6).

A special microvolt recording system has been installed at the CSSL Headquarters. The system provides automatic recording and tape punch output of as many as 144 micrometeorological elements every six minutes or each hour at our discretion. The system punches out identifiers ahead of each micrometeorological element so that the types may be fed directly into electronic computors for analyses. The system is still being "debugged" but promises to come into smooth and continuous operation soon.

Meteorological and snow records taken in 1958-59 and the status of data processing are shown in Table 3, Appendix A. Daily records for the CSSL Headquarters for the period July 1, 1958 to June 30, 1959, are given in Figure 2, Appendix B, and monthly summaries are given in Table 4, Appendix A. Daily streamflow for Castle Creek for the same period is shown in Figure 3, Appendix B.

The Station on Mt. Lincoln (Station L) has been discontinued. Icing of the instruments gave faulty records when we were most interested, that is during snowfall period. We are substituting the Blue Canyon records as our free air wind measurement station.

Cooperation--The Weather Bureau is cooperating in the studies by taking wind direction and velocity measurements for us at their Blue Canyon Station, 20 miles west of the laboratory at an elevation of 5,000 feet. We, in turn, are supplying daily meteorological, snow, and streamflow data to them which are used in the State Flood Forecasting Service. We are also supplying daily samples of streamflow and of new snowfall to the State Department of Public Health for analyses of radioactivity.

The basic snow measurements studies included an analysis of the applicability of the median snow water content of a snow course in determining the average value of a course. In the test, the median of 5 points of a snow course correlated as well with streamflow as the mean of 19 points. Details are given in paper number 15.

Plans--We plan to continue the basic meteorological measurements as at present until analyses indicate that some of the stations may be dropped. We will explore further the possibility of using the radioactive soil moisture probe in the measurement of snow density profiles.

Wind Effects on Snow Accumulation in the Forest (Study 1-7).

This study was inoperative during this year.

Plans--Analyses will be made of the relationship of shelter from the wind and eddying of the wind by forest cover to snow accumulation and melt in the 57 snow courses measured during 1957-1958 and 1958-59. Basic studies in the relation of snow accumulation and melt to wind will be made in the eight special snow courses with our new field going data logger-punchout system. This unit should be ready to go by the fall of 1959.

Cooperation--This study has been strengthened by the cooperation of the Weather Bureau in servicing and operating our wind recording instruments at their Blue Canyon Station.

Hydrologic Processes and Erosion Measurements, Onion Creek Watersheds (Study 1-8).

Summer soil moisture and precipitation losses and snow accumulation and melt were measured in a logged and unlogged forest and in a brush field. A water balance was computed for the logged and unlogged forest for the year. The logging was a "commercial diameter-limit cut" in which all trees greater than 18 inches in diameter were removed. Thirty-five thousand board feet per acre were removed from the unlogged stand of 37,000 board feet. We reported last year that this cutting increased snow water accumulation at the time of maximum accumulation by 7.1 inches for 1958. Corresponding snow water accumulation and melt in 1959, with about one half the amount of precipitation, is shown in the Table below:

Year and Treatment	Water Equivalent - Inches		
	March 9	April 6	May 7
1959			
Forest uncut	20.1	15.5	7.7
Forest cut	26.4	21.5	6.8
Difference	+6.3	+6.0	-0.9

Again in 1959 there was more water at the time of maximum pack in the cut forest--6.3 inches more. And again snowmelt in the cut area was faster so there was slightly more snow in the uncut forest at the time of the last spring snow measurement, 0.9 inches more water. This amount was nearly identical with the last measurement in 1958 when there were 0.6 inches more water left in the uncut forest.

Summer soil moisture losses were 0.9 inches less in the cut forest than in the uncut forest with the losses being 7.5 in the cut forest and 8.4 in the uncut forest for a 48-inch deep soil.

These data on snow accumulation and snowmelt and soil moisture losses were used in making some first estimates in the expected differences in water yield resulting from the logging. The water balance for the period April 15, 1958 to April 14, 1959, for the logged and unlogged forest are given in the last two columns of Table 5, Appendix A.

Plans--We intend to carry on the study for several years to find out how long forest cutting effects remain.

In addition, we will measure the soil moisture losses and snow accumulation in nearby brush areas for one more year before converting these areas to grass and to trees to determine the effects on water balance.

Basic Meteorological and Snow Measurements, Teakettle Experimental Area (Study 1-9).

The Pacific Gas and Electric Company again this year made regular weather observations and measurements for us at the station near Wishon Dam. These measurements are proving useful in working up our streamflow measurements at the Teakettle watersheds and will serve to characterize the years of the studies in these watersheds.

Plans--Meteorological measurements are needed in this area for at least one more year--until such time as adequate correlations with long term weather stations can be established. We are also asking the Pacific Gas and Electric Company to obtain another year's data on evaporation from snow in this area.

Water Yield (Study 1-10).

Monthly streamflow has been tabulated and watershed characteristics determined for some 130 streams, mostly on the Sierra west side. We are now ready to make analyses to determine the amount and timing of water yield from various elevations and topographic areas of the Sierra. The aid of economists has been solicited to make sure our results are put in terms most useful to the water users.

Two papers bearing on watershed analysis have been prepared. A paper on meteorological indexes of flood potential in watersheds was presented at the American Meteorological Society Session of the AAAS in Logan, Utah, June 16, 1958--paper number 17 at the end of this report. The second paper dealt with evaluation of forest effects on floods; it was presented at the Annual Meeting of the American Geophysical Union in Washington, D. C.--paper number 24, this report.

Plans--To begin analysis of streamflow and watershed data early in the fall of 1959.

Heat Equivalent and Snow in Openings and Forested Slopes (Study 1-11).

Analyses were made of the data from 1958 snow accumulation and melt at 57 snow courses, showing snow accumulation and melt in the forests of various densities, in forest openings of various sizes, and on various slopes. The snow in various forest conditions (average for all slopes) at the time of maximum snow accumulation, about April 22, 1958, and again after about one-half to two-thirds of the snow had melted, June 1, 1958 are given in the following tabulation:

Forest Condition	Snow Water - Inches		
	April 22	June 1	Melt
In forest openings	63.2	26.8	36.6
In forest adjacent to openings	56.0	25.1	30.9
In dense forest (80-100%)	48.1	19.0	29.1
In moderate forests (50-80%)	50.3	25.0	25.3
In open forests (20-50%)	57.7	25.0	42.0

Note that the maximum snow on April 22 and still on June 1, 1958 were in forest openings; maximum melt occurred there too. Minimum melt rates were found in forests, the least being in the moderate dense forests.

Moderately steep slopes (about 30 percent) were found to have higher melt rates than either steeper or less steep slopes. Most rapid melt rates occurred on the south and west slopes. Differences in melt rate on various parts of forest openings were discussed in the paper. The suggestion that snow accumulation might be a maximum in L-shaped openings on east and west slopes was proposed. The results were presented in a paper at the Salt Lake meeting of the Society of American Foresters and at the American Geophysical Meeting in Washington, D. C. See paper number 20 at the end of this report for further details.

Snow accumulation and melt have been measured again during the winter of 1958-59 at these 57 snow courses. Photo-canopy pictures have been taken at each of the 1,300 points involved; and have been interpreted for the 400 points with maximum differences in forest canopy. These data are now being analyzed to determine the variables that determine snow accumulation on various slopes.

Plans--To measure snow accumulation and melt at all of these points for one more year, attempting to get some measure of the heat received at each point during the year. To analyze and report the data currently.

Streamflow and Sediment Measurements, Castle Creek (Study 1-12).

One square mile of Castle Creek drainage was selectively logged in the summer of 1958. In addition, a freeway is to cross the watershed, with construction probably to start in 1960. We are evaluating the effects of the logging and will evaluate the effect of the freeway on snow accumulation and melt, streamflow, and sediment production. In making the evaluation we have started sampling the stream for suspended sediment in more places and more frequently; we have made detailed inventories of the forest cover, ground cover and erosion indicators prior to and following the logging; and we are making snow and soil moisture determination at logged and unlogged sites and at sampling points which cross the proposed freeway.

Suspended sediment concentration plotted against discharge of the 3.96 square mile Castle Creek Drainage Basin prior to the logging is shown in Figure 5. In general, streamflow is remarkably free of suspended sediment.

Plans--We intend to continue all measurements necessary to the evaluation of both the logging and the freeway on water in this basin, analyzing the data currently.

Winter Evapotranspiration in Relation to Forest and Terrain Characteristics (Study 1-13).

Snow evaporation results in the winter of 1958- and 1958-59 together with relationship of the evaporation to wind and atmospheric moisture were presented at the Western Snow Conference in Reno--paper number 21. Another paper gave the results of separate studies of condensation on snow patches, and some first measures of summer soil moisture losses--paper number 19. This paper was presented at the American Water Works Association meeting in Los Angeles.

Evaporation from the snow was measured daily in a small forest opening and in a 80 percent dense forest, at an elevation of 6,700 feet. Evaporation from January through June 1959 totaled 1.7 in the forest openings and 0.9 inches in the forest itself. In a short term study the snow evaporation in a meadow was one and a half times that of the small openings and snow evaporation on exposed ridge tops was as much as three times that of the openings. In mid-June of 1958 a snow patch was gaining nearly 3/100 of an inch of water per day due to condensation.

Plans--Extend the measurement of snow evaporation to more frequent sampling of exposed sites. Continue to search for a method of measuring transpiration of trees during the winter, exploring nuclear tracers, charge protons, and other new methods.

Heat Balance Components in Forest and Openings (Study 1-14).

Instrumentation for the measuring, automatic recording and punchout of the meteorological and heat elements needed in heat balance studies has been brought forward this year. After minor "debugging,"the instrument promises to speed computation of heat balance components in forests and openings.

Plans--We plan to complete testing the instruments and have them ready for measurement of heat flow components by October, 1959. A specialist in heat flow components has joined our staff and will head these studies.

Evaluation of Summer Evapotranspiration in Relation to Forest Sites (Study 1-15).

Summer soil moisture losses and losses of summer precipitation were measured at 45 sites in the Castle Creek Basin. The first analysis indicates that for a 75-day period--July 1 to October 15, 1958--losses from a soil 4-foot deep were as follows:

Condition	Water Losses - Inches
Old Growth Red Fir Forests	5.1
Young Red Fir Forests	4.8
Wyethia (Wild Sunflower)	3.5
Bare Ground	1.3

An additional loss of 2.0 inches of summer precipitation occurred in the period. A paper describing the methods and giving some results was presented at the American Geophysical Union meeting at Stanford--paper number 18.

Plans--To continue the study through the summer of 1959. To analyze the data currently. To try to establish relationships between meteorological elements and water losses on forest sites.

Swain Mountain Snow Studies (Study 1-16).

Snow accumulation and melt and summer evapotranspiration losses were measured in a forest cut in two ways and in uncut forests. The forest was cut in strips five chains wide (2 tree heights across) and in a block cut area of 17 acres. Summer soil moisture losses for a 4-~~inch~~ foot deep soil (the average soil depth) are shown in the following tabulation:

Condition	Soil Moisture Loss
	inches
Strip Cutting	
Cut	3.4
Uncut	6.6
Difference	3.2
Block Cutting	
Cut	4.6
Uncut	7.3
Difference	2.7

In the cut areas, deep soils (90 inches deep) and the 4-foot deep soil lost the same; however, in the uncut areas the deep soils lost 1.4 inches more water.

At the time of maximum snowpack accumulation there was 10 inches more water in the cut strip than in the adjacent uncut forests; the block cut had 5 inches more than the uncut forests.

The effects of these strip and block cutting on the water budget for a year with 46-47 inches of precipitation have been estimated (Table 5). It may be seen that the cut strip saved 8.6 inches of water and block cutting saved 6.3 inches of water; this is notably more than the 3.4 inches of water saved by the commercial selection cut shown in the same table. The results of this study were reported at the Western Snow Conference and have been submitted for publication in the Proceedings. Paper number 22 at the end of this report.

Plans--Continue the soil and snow moisture measurements, intensifying the soil moisture sampling under the different slash disposal methods--piled and burned slash, slash lopped to 18 inches, and slash left untouched. When exclosures are made as part of a game habitat study in this area, we will study the effects of such exclosures on soil moisture losses and snow.

Cooperation--Our Division of Forest Management Research is cooperating by taking the winter snow measurements.

Sagehen Cooperative Study of Streamflow, Sedimentation, and Fish Habitat, (Study No. 1-17).

Summer soil moisture losses were measured in a brush field being converted to a pine forest. In 1958 the brush was removed from a 12 percent, south slope, by bulldozing and windrowing the brush; pine was planted. Summer soil losses in the period July 24 to September 30, 1958 for a 4-foot and 7-foot soil depth are given in the following tabulation:

Condition	Soil Moisture Loss - Inches	
	4-foot Soil	7-foot Soil
Converted Brush (to small pine)	0.7	0.8
Unconverted Natural Brush	3.4	6.0
Difference	2.7	5.2

Thus, the conversion saved 2.7 inches of water for a 4-foot soil and nearly double this in the soils 7 feet deep.

As far as could be determined by indicators of erosion, the windrowed brush was effective in stopping erosion; apparently no erosion reached natural streams.

Plans--Continue the evaluation of the hydrologic processes, particularly the summer soil moisture losses under the treated and untreated brush area. Continue measurements of streamflow and analyses of suspended sediment samples.

Cooperation--The University of California, Department of Zoology, is cooperating by taking samples of suspended sediment for analyses. The USGS is taking the streamflow measurement. Tahoe National Forest is applying the treatment--clearing the brush and planting.

Erodibility of California Wildland Soils, Relation to Sedimentation (Study 1-18).

Soil samples were taken at 177 standardized sites (same slope, aspect, precipitation and elevation) differing only in geology, in the wildlands of northern and central California. Physical characteristics of these soils are being determined in the laboratory, in an attempt to obtain indexes of the erodibility of soils developed on various parent rock materials.

Mechanical analyses of these samples have been completed as part of the plan for testing the relation of sediment production of watersheds to the physical characteristics of soils.

Plans--Complete the physical analyses of the soils and test the relationships of these characteristics to sediment production from watersheds of California wildlands.

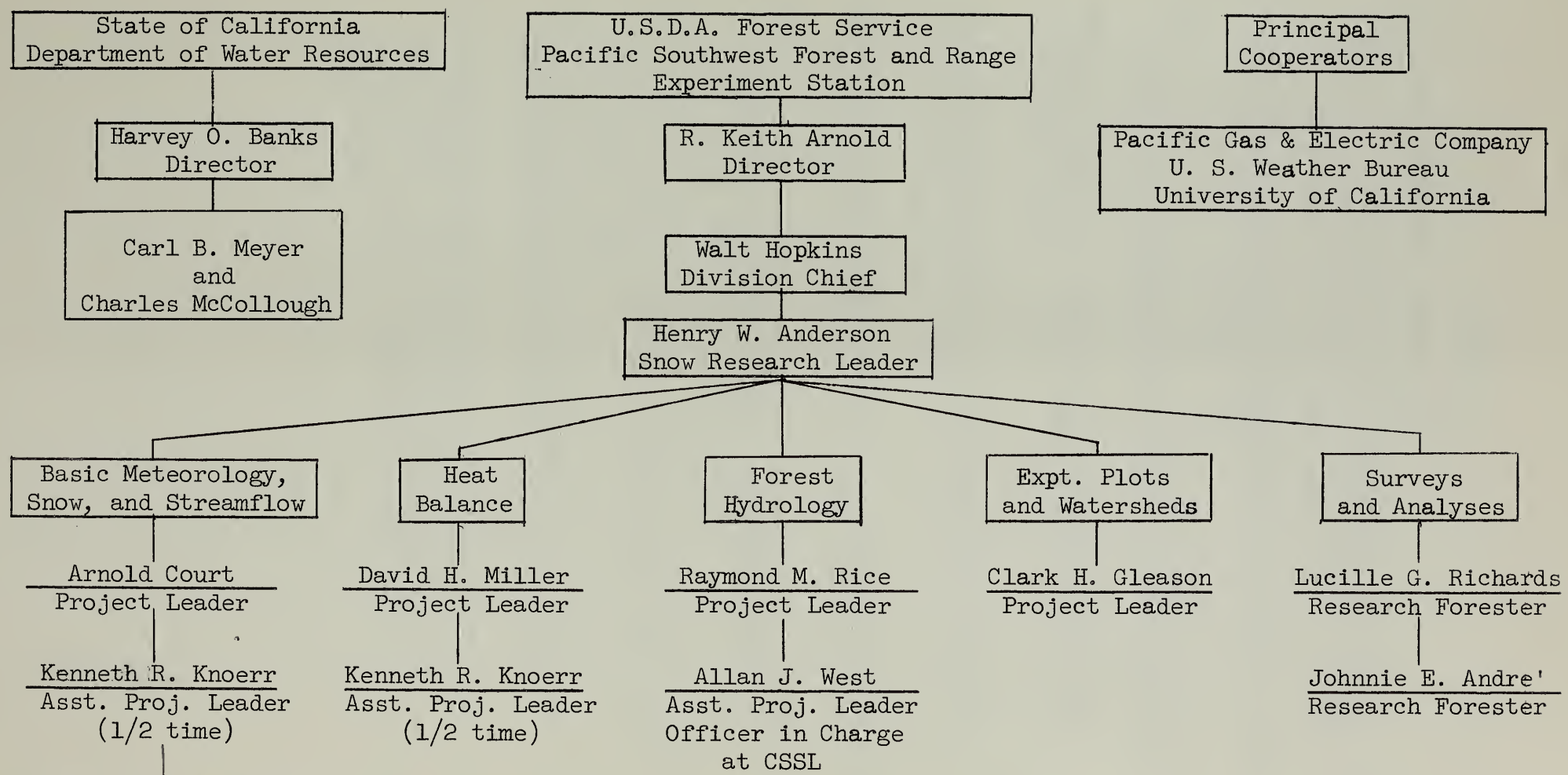
Cooperation--The University of California, Department of Soils, is cooperating by making their laboratory facilities available.

ORGANIZATION

The organization of the California Cooperative Snow Management Research is shown on the next page. In all, nine technicians are working directly on the project, two of them, half time. About an equal number of forestry aids and other field and office assistants help keep the project running.

ORGANIZATION CHART - CALIFORNIA COOPERATIVE

SNOW MANAGEMENT RESEARCH 1959-60



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Special Services:	C. M. Walker, Editor; Wm. O'Regan, Statistician; R. M. Miller, Data Processing
Admin. Services:	F. W. Bacon, Chief, Divn. Station Management

REPORTS

Publications (July 1956--June 1958)

1. "Forest cover effects on snow accumulation and melt, Central Sierra Snow Laboratory" by H. W. Anderson. Trans. Amer. Geophys. Union 37(3):307-12, 1956, 38(1):116, 1957.

2. "Anti-freezing hoods for V-notch weirs" by Carl O. Johannessen. Jour. Forest. 55(8)590, 1957.

3. "Operation Wet-Blanket gets underway" by H. W. Anderson, Abstracted in Trans. Amer. Geophys. Union 38(3)414, 1957.

4. "Relating sediment yield to watershed variables" by H. W. Anderson. Trans. Amer. Geophys. Union 38(6): 921-924, 1957.

5. "Soil-vegetation survey of a Central Sierra Snow Zone watershed" by R. E. Nelson. CF&RES Misc. Paper 21, 43 pp. illus. Dec. 1957.

6. "Snow on forested slopes" by H. W. Anderson and T. H. Pagenhart. 25th Ann. Western Snow Conf. Proc. pp. 19-23, 1957.

7. "Wind direction during snowfall at Central Sierra Snow Laboratory" by Arnold Court. 25th Ann. Western Snow Conf. Proc. pp. 39-43, 1957.

8. "New meteorological and snow studies in the Central Sierra" by K. J. Walsh, 25th Ann. Western Snow Conf. Proc. pp. 43-45, 1957.

9. "Snow surveys from the snow surveyor's side" by P. J. Wyckoff, 25th Ann. Western Snow Conf. pp. 57-59, 1957.

10. "Watershed management--an annotated bibliography of erosion streamflow, and water yield publications by the California Forest and Range Experiment Station" by Clark H. Gleason, CF&RES Tech. Paper 23, 79 pp., illus. Jan. 1958.

Publications (July 1958--June 1959) (copies attached except No. 11)

11. "Progress Report, 1957-58, Cooperative snow management research" by H. W. Anderson, CF&RES, 56 pp. illus., proc., June 30, 1958.

12. "Water yield control through management in snow pack watersheds" by Henry W. Anderson. Proc. First Intersociety Conf. on Irrig. and Drainage, pp. 13-18, March 1959.

13. "Snow management research in High Sierra Range" by R. M. Rice. Jour. of Range Mgmt. 12:13-16, 1959.

14. "Forest shade related to snow accumulation" by H. W. Anderson, R. M. Rice, and A. J. West. 26th Ann. Proc. Western Snow Conf. pp. 21-31, 1958.

15. "Selection of best snow course points" by Arnold Court. 26th Ann. Proc. Western Snow Conf. 1-12, 1958.

16. "Progress in snow management research in California" by H. W. Anderson. 26th Ann. Proc. Western Snow Conf. pp. 12-21, 1958.

17. "Rain-snow flood sources, meteorologically defined" by H. W. Anderson. Presented at Amer. Meteorol. Soc. Session of AAAS at Logan, Utah, June 16, 1958. (Abstract) Bul. Amer. Meteorol. Soc. 39(3):174-5, 1958.

18. "Summer evapotranspiration measurements using a radioactive soil moisture probe" by K. R. Knoerr. Presented at SW Pac. Meeting Amer. Geophys. Union, 1959. (Abstract) Jour. Geophys. Res. 64(6):691, 1959.

19. "Winter and summer water losses in the High Sierra" by A. J. West and K. R. Knoerr. Jour. Amer. Water Works Assoc. 51(4):481-88, 1959.

20. "Snow in forest openings and forest stands" by H. W. Anderson, R. M. Rice and A. J. West. Proc. Soc. Amer. Foresters, pp. 46-50, 1958.

Manuscripts Accepted for Publication

21. "Snow evaporation and condensation" by A. J. West. Presented at the Western Snow Conference, 1959. Submitted to them for publication in Proceedings, 1959.

22. "Logging effects on snow, soil moisture and water losses" by H. W. Anderson and C. H. Gleason. Presented at Western Snow Conference, 1959. Submitted to them for publication in Proceedings, 1959.

23. "Snow management research in the Sierra Nevada--a review and a look ahead" by Walt Hopkins. Submitted to Western Snow Conference for publication in Proceedings, 1959.

24. "Forest effects on floods in northwestern United States" by H. W. Anderson and R. L. Hobba. Submitted for publication in Proc. Symposium on Forests and Water, Hannover-Munden, Germany, Sept., 1959.

File Reports

1. "Radiation Computations" by Arnold Court. PSWF&RES File Report, Oct. 31, 1958, 3 pp. proc.

2. "Dewcel-thermocouple formulas" by Arnold Court. PSWF&RES File Report, Feb. 6, 1959, 4 pp. proc.

3. "Readings for geographers in the literature of hydrology" by D. H. Miller, PSWF&RES File Report, Jan. 20, 1959, 21 pp. proc.

4. "Nuclear-Chicago P-19 soil moisture probe--comments on first year's use for soil moisture measurements" by K. R. Knoerr, PSWF&RES File Report, Mar. 5, 1959, 6 pp. proc.

5. "Notes on discharge calculations for V-notch weirs" by H. W. Anderson, PSWF&RES File Report, May 4, 1959, 3 pp. proc.

APPENDICES

A. TABLES

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C. REPRINTS, 1958-59 publications

APPENDIX A

TABLES

Table 1.--Forest and slope characteristics for elevations above 5,000 feet on the west side of the Sierra Nevada Mountains Latitudes 35°57-1/2' to 39°57-1/2'

ITEM	ACREAGE	PERCENT OF AREA
FOREST OPENINGS		
Less than 132 ft. across 1/	2,978.9	22.5
Less than 132 ft. across 2/	11.8	.1
132-263 ft. across	131.6	1.0
264-527 ft. across	377.5	2.9
528-1056 ft. across	728.8	5.5
>1056 ft. across	6,412.5	48.3
Total	10,641.1	3/ 80.3
FOREST DENSITY		
0-14 percent	7,662.2	57.9
15-39 percent	2,220.6	16.8
40-69 percent	2,681.7	20.2
70-100 percent	675.5	5.1
Total	13,240.0	100.0
CONDITIONS IN OPENINGS 4/		
Brush	2,271.4	29.6
Grass-Herb	928.3	12.1
Rock-Ground	3,628.1	47.4
Trees	344.7	4.5
Other	489.7	6.4
Total	7,662.2	100.0
SLOPE		
0-10 percent	-	13.3
11-20 percent	-	29.0
21-30 percent	-	18.7
31-40 percent	-	20.3
41-50 percent	-	7.9
51-60 percent	-	4.2
61-70 percent	-	2.7
over 71 percent	-	3.9
Total	-	100.0
SLOPE DIRECTION		
North	-	19.0
East	-	20.3
South	-	26.0
West	-	32.3
Level	-	2.4
Total	-	100.0

1/ Collectively determined.
2/ Individually measured openings consisted of roads and streams.
3/ Percent of total area.
4/ Openings greater than 132 feet across.

Table 2.--Experimental watershed reservoirs, streamflow measurement devices and sedimentation, 1956-57 and 1957-58.

Name		Major River Basin	Drainage Area	Elevation	Weir Type	Reservoir Capacity	Sedimentation 1956-1957	Sedimentation 1957-58
			Sq. mi.	Ft.		A.F.	A.F./Sq. mi.	A.F./Sq.mi.
Teakettle	No. 1	N. Fk. Kings	0.77	6410-8000	5'90°V) 2x6' Cip.)	0.351	0.050	0.055
	No. 2	N. Fk. Kings	0.85	6920-8160	5'90°V) 2x6' Cip.)	0.106	0.020	0.018
	No. 2a	N. Fk. Kings	0.27	6890-7940	5'90°V	0.066	0.032	0.021
	No. 3	N. Fk. Kings	0.86	6708-8100	5'90°V) 2x6' Cip.)	0.117	0.017	0.007
	No. 7	N. Fk. Kings	1/ 0.11	6800-7100	2'90°V	0.204	0.444	0.020
Onion Creek	No. 1	N. Fk. American	0.19	6160-7300	3'120°V	0.114	2/	0.096
	No. 2	N. Fk. American	0.48	6150-7600	4-1/2'120°V	0.134	2/	0.083
	No. 3	N. Fk. American	0.65	6300-7896	5'120°V	0.191	3/	-
	No. 5	N. Fk. American	0.39	6560-8383	4'120°V	0.177	2/	0.112
	No. 7	N. Fk. American	0.87	6110-7980	5-1/2'120°V	0.075	3/	-
Castle Creek	No. 1	So. Fk. Yuba	3.96	6865-9103	12' Parshall, 149°30'V	None	4/	-
Sagehen Cr.	No. 1	Truckee	11.1	6300-8000	Variable V Section,	None	4/	-

1/ Subject to revision after final field check of areas.
2/ Sediment accumulation started 1957-58.
3/ Sediment accumulation started 1958-59.
4/ Watershed has no sediment basin. Suspended sediment samples are periodically taken.

Table 3.--Meteorological, snow, and soil moisture records taken and status of data processing, 1958-1959

STATION	ELEMENT	INSTRUMENT	FREQUENCY OF READINGS	PERIOD COVERED FROM	PERIOD COVERED TO	PROCESSING STATUS
H Headquarters, CSSL	Precipitation	Recording Gage	Continuous	7-1-58	6-30-59	Hourly tabulations made; published by U.S. Weather Bureau in "Hourly Precipitation Data."
	Snowfall	Snow Board	Daily	11-10-58	5-24-59	Plotted, cumulatively.
	Snowpack	Special Course	Daily, 0800	11-10-58	5-24-59	Plotted on graph.
	Air Temperature					
	Max. & Min.	Thermometers	Daily, 0800	7-1-58	6-30-59	Plotted on graph.
	Max. & Min.	Thermograph	Continuous	7-1-58	6-30-59	Not tabulated.
	Current	Thermometers	Daily, 0800	7-1-58	6-30-59	Not tabulated.
		Thermograph	Continuous	7-1-58	6-30-59	Not tabulated.
	Air Moisture	Psychrometer	Daily, 0800	7-1-58	6-30-59	Not tabulated.
	Air Moisture	Hygrograph	Continuous	7-1-58	6-30-59	Air moisture at time of max. temp. plotted on graph.
	Atmospheric Pressure	Merc. Barometer	Daily	7-1-58	6-30-59	Not tabulated.
	Atmospheric Pressure	Barograph	Continuous	7-1-58	6-30-59	Not tabulated.

Table 3.--Continued

STATION	ELEMENT	INSTRUMENT	FREQUENCY OF READINGS	PERIOD COVERED FROM	PERIOD COVERED TO	PROCESSING STATUS
M Upper Meadow Castle Creek	Snowfall	Snow Board	Monthly	12-28-58	3-4-59	Not tabulated.
	Snowpack	Snow Course	Monthly	12-28-58	5-4-59	Tabulated, State reports.
	Air Temperature Max. & Min.	Thermometers	Monthly	10-3-58	3-4-59	Not tabulated.
O Onion Creek	Precipitation	Recording Gage	Continuous	7-1-58	6-30-59	Not tabulated.
	Snowfall	Snow Board	Bi-weekly	12-30-58	4-28-59	Not tabulated.
	Snowpack	Snow Course	Bi-weekly	1-14-59	3-31-59	Tabulated, State reports.
	Air Temperature Max. & Min.	Thermometers	Bi-weekly	7-1-58	6-30-59	Not tabulated.
	Max. & Min.	Thermograph	Continuous	7-1-58	6-30-59	Not tabulated.
	Current	Thermograph	Continuous	7-1-58	6-30-59	Not tabulated.
	Air Moisture	Hygrograph	Continuous	7-1-58	6-30-59	Not tabulated.
	Soil Moisture	Nuclear Probe and Scaler	Monthly during summer season	8-7-58	6-17-59	Logged areas have been summarized and report written.
R Ridge	Snowfall	Snow Board	Monthly	12-30-58	4-28-59	Not tabulated.
	Snowpack	Snow Course	Bi-weekly	2-4-59	4-28-59	Not tabulated.

Table 3.--Continued

STATION	ELEMENT	INSTRUMENT	FREQUENCY OF READINGS	PERIOD COVERED FROM	PERIOD COVERED TO	PROCESSING STATUS
Blue Canyon	Precipitation	Recording gage (from W. B.)	Continuous	7-1-58	6-30-59	Hourly tabulation made by W. B. Combined into monthly summary.
	Wind Speed and Direction	Esterline-Angus Recorder	Continuous	7-1-58	6-30-59	
Wishon Dam	Air Temperature					
	Max. & Min.	Thermometers	Daily, 0745	7-1-58	6-30-59	Checked and scatter diagrams made comparing Wishon Dam with Big Creek PH #1 Grant Grove and Huntington Lake.
	Max. & Min.	Thermograph	Continuous	7-1-58	6-30-59	
	Current	Thermometers	Daily, 0745	7-1-58	6-30-59	
	Current	Thermograph	Continuous	7-1-58	6-30-59	
	Air Moisture	Psychrometer	Daily, 0745	7-1-58	6-30-59	
	Air Moisture	Hygrograph	Continuous	7-1-58	6-30-59	Not tabulated.
	Wind miles	Anemometer	Daily, 0745	7-1-58	6-30-59	Not tabulated.
	Snow Evaporation	Snow Pans	Monthly	1-17-59	3-4-59	Tabulated and summarized.

Table 3.--Continued

STATION	ELEMENT	INSTRUMENT	FREQUENCY OF READINGS	PERIOD COVERED FROM	PERIOD COVERED TO	PROCESSING STATUS
Swain Mt.	Snowpack	Snow Course	Monthly	2-3-59	6-1-59	Summarized and report written.
	Soil Moisture Data	Nuclear Probe	Monthly	7-4-58	6-3-59	Logged areas summarized and report written.
Sagehen	Soil Moisture Data	Nuclear Probe	Monthly	7-24-58	5-27-59	Summarized.

Table 4.--Monthly climatic summary, Central Sierra Snow Laboratory, 1958-1959

Month	AIR TEMPERATURES: Averages: Max.	Min.	Mean	Extremes: Highest	Date	Lowest	Date	Total Precipitation	Cum. Daily Snow w.e. 1/	Month-end Snow w.e. 1/
1958	F°	F°	F°	F°		F°		- - - - - inches - - - - -		
July	71.7	41.6	56.6	84	28	34	1	0.53	0.00	0.0
Aug.	76.1	45.3	60.7	82	6,13	38	4	1.20	0.00	0.0
Sept.	68.3	39.7	54.0	80	1,7	27	24	0.84	0.00	0.0
Oct.	62.6	34.4	48.5	74	4,5	25	21,30	0.46	0.00	0.0
Nov.	46.8	25.3	36.0	61	8	1	17	3.15	1.82	0.0
Dec.	45.2	26.6	35.9	60	4	15	29	3.38	3.26	3.5
1959										
Jan.	38.1	19.0	28.6	54	18	1	3,4	14.77	10.81	15.5
Feb.	33.2	16.8	25.0	46	6	-6	9	14.62	12.70	28.5
Mar.	46.1	22.7	34.4	57	12	13	25	3.39	2.98	26.5
Apr.	53.7	26.5	40.1	65	30	19	18	2.90	2.26	8.5
May	51.0	28.5	39.8	71	13	10	3	3.33	2.35	2.0
June	70.0	38.2	54.1	81	21,22	28	7	0.00	0.00	0.0
Total								48.57	36.18	
Average	55.2	30.4	42.8							

1/ Water equivalent.

Table 5.--Logging effects on water balance, Swain Mountain and Onion Creek Experimental Forest, April 15, 1958 - April 14, 1959[1]

ITEM	FOREST CONDITION					
	Strip Cut		Block Cut		Commercial Cut	
	Logged	Unlogged	Logged	Unlogged	Logged	Unlogged
FOREST COVER - PERCENT						
Hemispherical cover (Hc)	42	87	49	79	63	82
WATER BUDGET - INCHES						
Total precipitation	46.15				47.08	
Winter and spring						
Precipitation	38.1	38.1	38.1	38.1	41.1	41.1
Interception losses[2]	0.4	3.8	0.9	3.2	2.1	3.7
Evapotranspiration[3]	0.9	2.9	1.2	2.5	1.8	2.7
Summer						
Precipitation	6.9	6.9	6.9	6.9	4.7	4.7
Soil moisture losses[4]	3.4	6.6	4.6	7.3	6.5	7.4
Fall						
Precipitation	1.2	1.2	1.2	1.2	1.3	1.3
Total losses	12.8	21.4	14.8	21.1	16.4	19.8
Water yield	25.3	16.7	23.3	17.0	24.7	21.3
Difference	8.6		6.3		3.4	

1/ Seasonal delineation: Winter and spring = Apr. 15-30, 1958; May 1-31, 1958; Nov. 1, 1958 - Apr. 14, 1959. Summer = June 1 - Aug. 31, 1958. Fall = Sept. 1 - Oct. 31, 1958. Differences in snowpack on April 15, 1958 and April 14, 1959 not included in yield--add 25 inches for Swain Mt. and 32 inches for Onion Creek.

2/ Winter and spring estimated from: Interception loss = 0.2 x Precipitation x [(Hc - 37)/100].

3/ Estimated from Evaporation (E) plus Transpiration (T), where E = 1.5(1-Hc/100) and positive values only of T = 6[(Hc-42)/100].

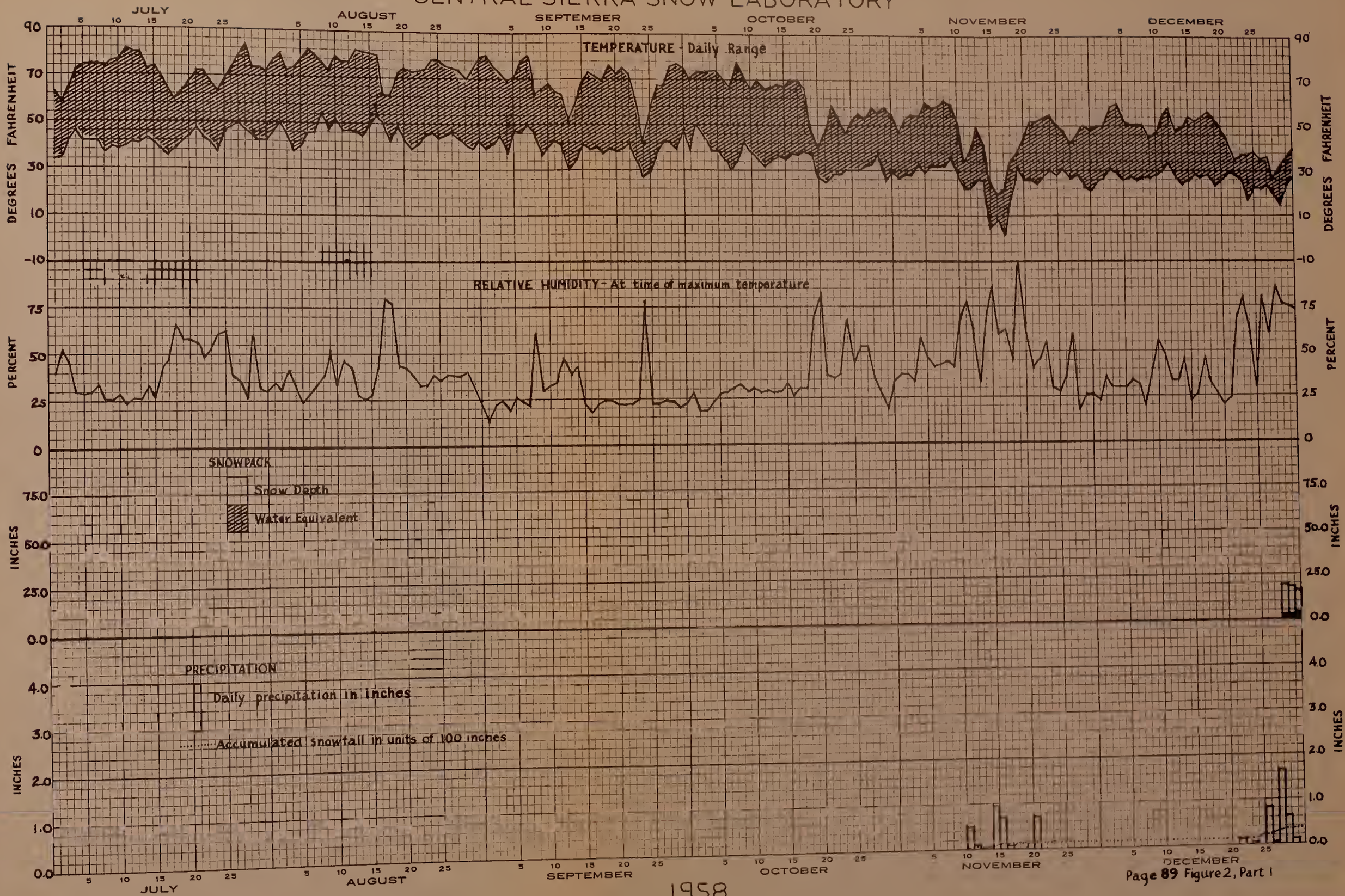
4./ For soil 48 inches deep.

APPENDIX B

FIGURES 2-4

SYNOPSIS OF HYDROMETEROLOGICAL ELEMENTS 1958 - 1959
CENTRAL SIERRA SNOW LABORATORY

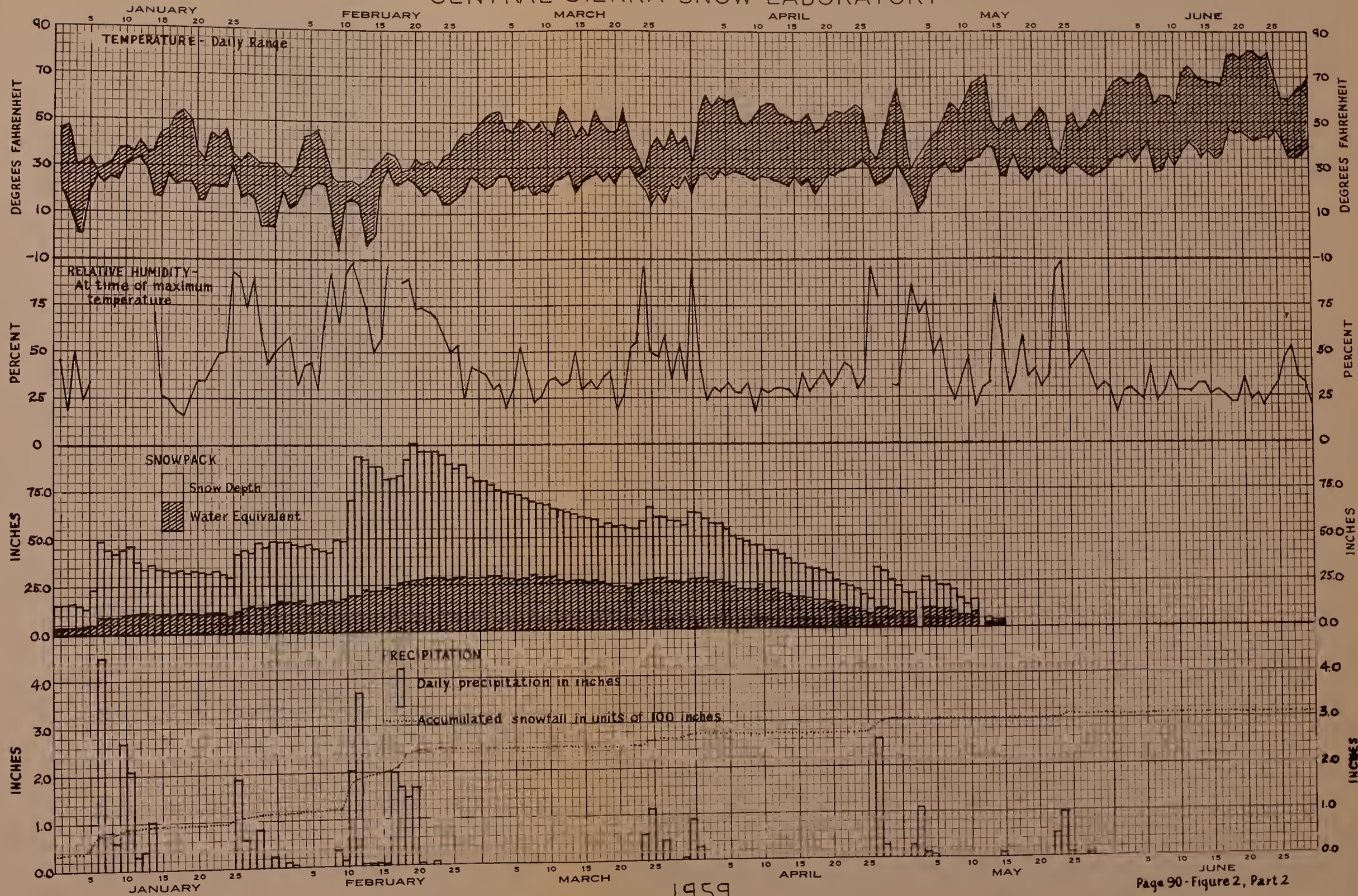
BY MSH & FFA
JULY 1959



1958

SYNOPSIS OF HYDROMETEROLOGICAL ELEMENTS 1958-1959
CENTRAL SIERRA SNOW LABORATORY

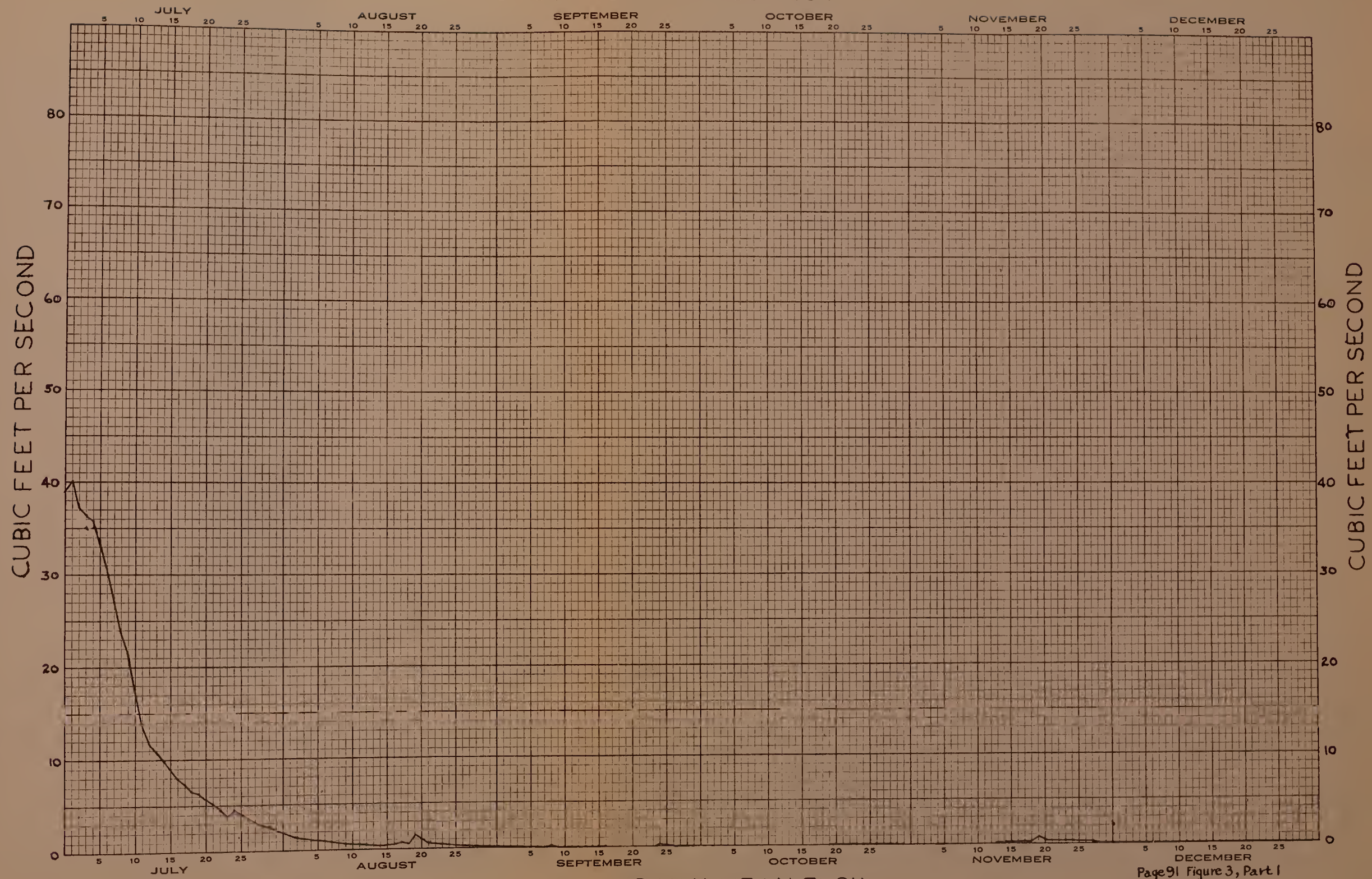
BY MSH & FFA
JULY 1959



1959

BY FFA
JULY 1959

STREAMFLOW
CASTLE CREEK 1958-1959



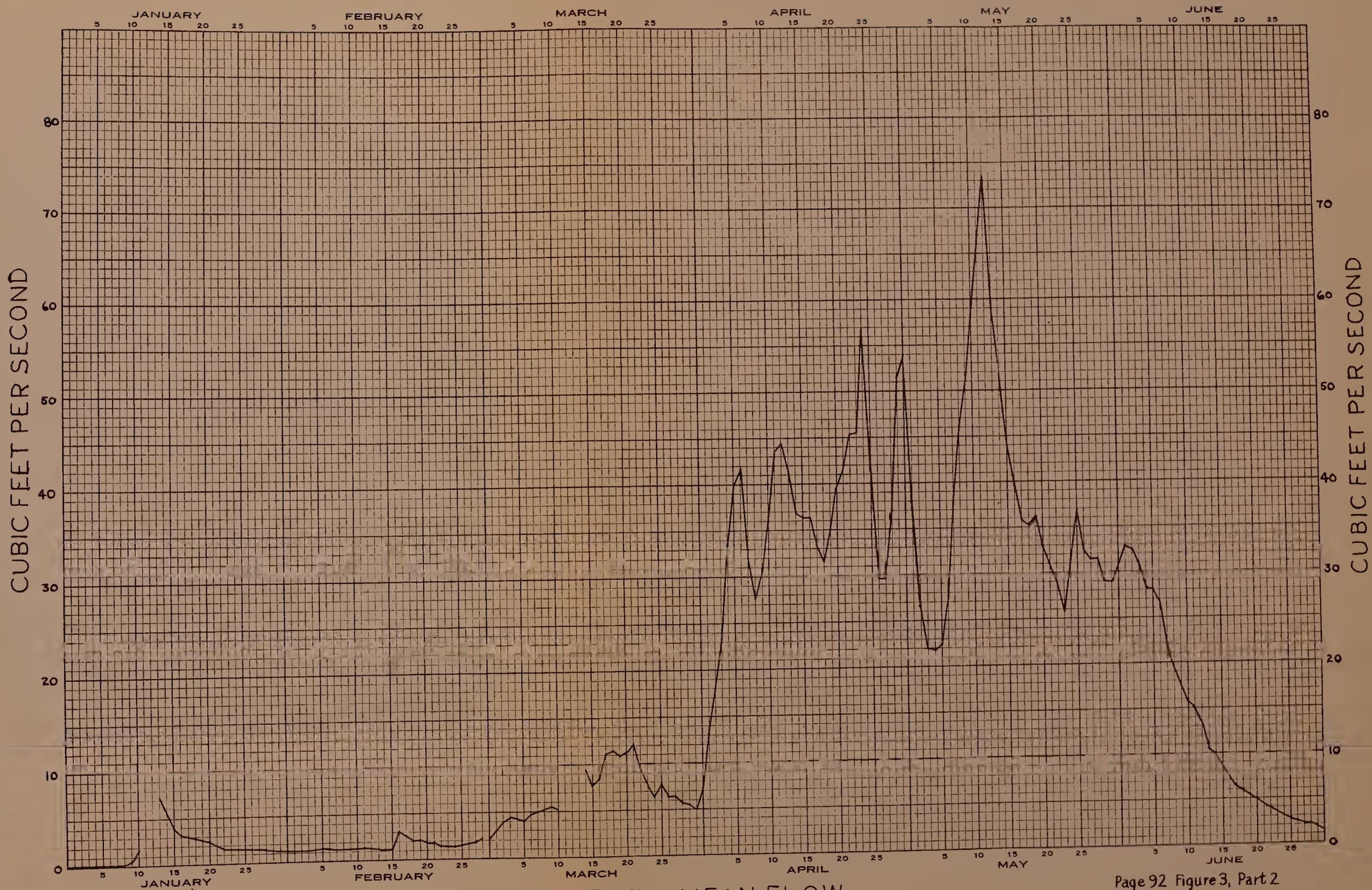
Provisional Record

DAILY MEAN FLOW
1958

Page 91 Figure 3, Part 1

BY FFA
JULY 1959

STREAMFLOW
CASTLE CREEK 1958-1959



Provisional Record

DAILY MEAN FLOW
1959

Relation of suspended sediment concentration to discharge,
Castle Creek, May 18, 1957 to July 21, 1958.

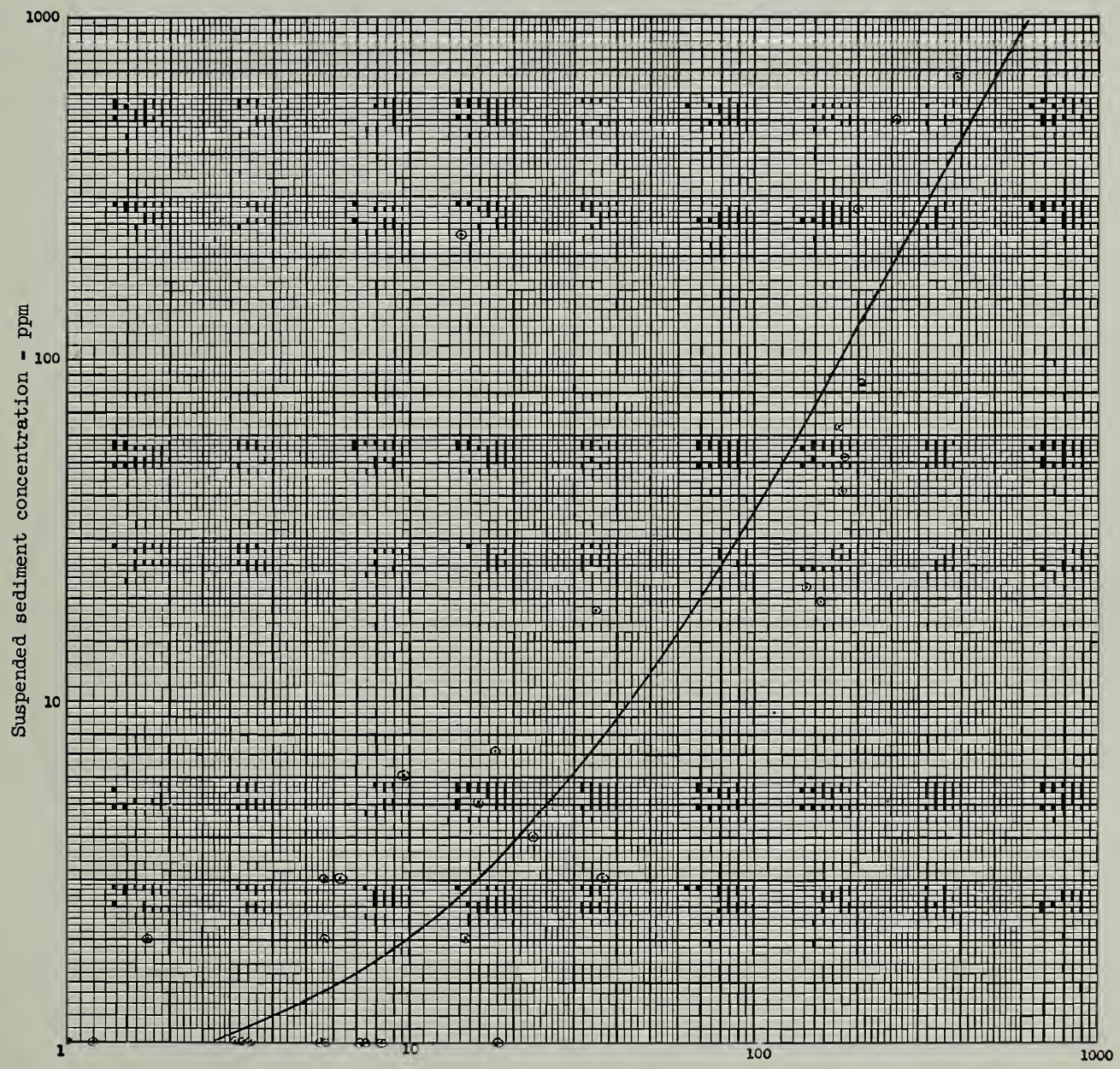


Figure 4